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GEOPHYSICAL VARIABLES AND HUMAN BEHAVIOR: XIX. STRONG TEMPORAL RELATIONSHIPS BETWEEN INCLUSIVE SEISMIC MEASURES AND UFO REPORTS WITHIN WASHINGTON STATE

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Summary.—Monthly measures of general unidentified flying-object reports (UFORs) and a specific subsample of luminosity-type reports (LRs) were compared with monthly variations in several seismic indices within Washington state for the years 1970 to 1976. A strong correlation occurred between the magnitude of a measure of the total energy released in a month and the time since the previous peak in UFORs and LRs. Percentage changes in UFORs and LRs with respect to the previous month were not correlated significantly with the occurrence of larger magnitude ($M \geq 2.0$) quakes but were moderately to strongly correlated with the numbers and percentage changes from the previous month in events of smaller magnitude ($1.0 \leq M < 2.0$). These seismic events also showed a systematic variation in lag time with the larger displays of seismic energy. Peaks in both UFORs and small magnitude events occurred between 0 to 6 mo. before increments with the larger seismic energy values; the average lag was about 2 months for both phenomena. Maximum correlations between numbers of UFORs and LRs and the numbers of events of smaller magnitude occurred when increments used in analysis averaged about 3 months. These analyses indicate that systematic and intricate relationships between samples of UFORs and earthquake measures are evident when the latter reflect a more representative sample of seismic events within the test area.

One hypothesis (Persinger, 1976; Persinger, 1983a) predicts that most reports of classic unidentified flying objects indicate the presence of environmental stimuli. They are correlated with changes in stress and strain within the earth's crust. Since direct measures of these processes are not available, they are inferred by the occurrence of earthquakes within the region where the reports of unidentified flying objects (UFORs) have been displayed. Several previous studies (Persinger, 1980, 1981, 1983b, 1983c) have suggested that the relationship between UFORs and earthquake activity can be recognized when multiple regression-time series analyses are applied over long intervals to optimal spatial and temporal increments of observation.

Not all analyses have yielded statistically significant correlations between numbers of UFORs and the numbers of earthquakes from different categories of maximum intensity. Unpublished analyses by E. Mantle for the Western

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Mountain Region and by M. A. Persinger for the Washington-Oregon area did not show any coupling between UFORs and quakes of various intensities when either 1-mo. or 6-mo. increments of analyses were employed. The hypothesis simply may not apply in these areas or periods. UFORs are not expected to be derived from a solitary source of variance even over large spaces (10^6 km^2). Indeed, UFOR samples from a very small subset of the earth's surface could contain minimal tectonogenic contributions.

Alternatively, the hypothesis may have been supported had the appropriate temporal "window" been selected. Whereas fixed, 6-mo. increments of analyses may reflect the strain-UFOR process in some areas (Persinger, 1980, 1981, 1983b), other regions, within which the dynamics of the states of stress are changing at different rates, may require larger, smaller, or even non-fixed temporal increments of analyses. Similarly, whereas some areas may demonstrate an optimal UFOR-seismic lag of only one increment, other spaces may show variable lags depending upon the magnitudes of the impending seismic events. If luminosities are coupled to geological factors, then the well-known complexity of such factors should be reflected in the characteristics of the luminosities.

Refutation of the hypothesis in some areas may also reflect insufficient sampling from both the UFOR and seismic populations. Previous analyses have depended almost exclusively upon the numbers of quakes with different maximum intensities. They typically represent only a small component of the total seismic set and are limited by human detection. Measures of magnitude, on the other hand, can represent ratio scales of energy release and are determined by instrumentation. The numbers of magnitude-measured events exceed reports of intensity by factors of ten and are limited only by the surface density and homogeneity of the seismographic network. We expect the previous multivariate patterns (over time) of earthquake intensities that have been associated with UFORs to also be correlated with more inclusive single measures of seismic activity or energy display. However, the isolation of a single or composite seismic measure that maximally correlates with luminosity measures would more clearly delineate the relationship between the two phenomena.

Much of the previous research (but not all; Persinger, 1983d) has relied upon the total sum of UFORs derived from different classifications. Considering the high bivariate and multivariate r values reported, this pattern may indicate that either most UFORs are generated from the same source of variance or some non-specific characteristic of human behavior (reporting) has confounded the analyses since total UFORs may also include unsubstantiated or questionable reports and may not indicate veridical events. The inclusion of non-tectonogenic UFORs within the pool would not be a major difficulty if one assumed that they constituted more or less a constant baseline of noise upon which the tectonogenic UFORs vary systematically; the latter would still

be responsible for the major source of variance coupled to the seismic measures. This problem could be attenuated by sampling-specific types of UFORs as defined by shared perceptual characteristics.

The following analyses were completed to determine if the relationship between UFORs and seismic activity would be more evident within an area that had previously *not* shown the effect (apparent refutation of the hypothesis) if more complete samples (approaching the total population) of seismic activity and more precise differentiation of UFORs were completed. Washington state and the adjacent Oregon region were selected since previous analyses of data from the Center for UFO Studies (CUFOS) and intensity measures (Persinger, 1980) for this region indicated no statistically significant relationship when 6-mo. increments were selected. However, a very homogeneous sample of UFORs collected within a small subset of this area, the Toppenish region, has been shown to vary systematically over several years as a function of the crustal depth and linear distance of the monthly magnitudes of seismic events[3] so one month was selected as the basic increment for the present analysis.

METHOD

Earthquake data for Washington state were obtained on magnetic tape from the University of Washington seismological network.[4] The tape contained detailed information for each seismic event, including temporal parameters (day, month, year), magnitude, and depth. UFO data (UFOCAT file) were obtained on magnetic tape from the Center for UFO Studies (CUFOS).[5] The information contained total numbers of uncategorized and categorized reports per month within the Washington and adjacent Oregon area. Types of UFORs ranged from 0 to 9 and reflected increasing stages of strangeness in the data (Saunders, 1978). The period between June 1970 and June 1976 (n = 72 mo.) was selected for analyses. This interval was 1.5 yr. after the beginning of the University of Washington data base and 1.5 yr. before a conspicuous decline in the numbers of reports within the CUFOS file.

Two UFOR measures were selected. The first measure, called *general* UFORs was calculated by subtracting the numbers of Type 0 (phenomena definitely not classified as UFOs), Type 1 (perceptual phenomena reported as "stationary" through the periods of observation or within the velocity range of heavenly bodies), and Type 2 (phenomena that moved at a continuous trajectory but with speeds greater than 15° per hour) from the total numbers of reports. Consequently, the general UFOR measure included the stranger classifications and the unclassified reports. The latter were included in this analysis since they had not been definitely designated as Types 0, 1, or 2 events. A

[3]J. S. Derr & M. A. Persinger, Relations among natural nocturnal lights and earthquakes in southern Washington. [Unpublished manuscript; cf. *Eos*, 1983, 64(45), 762]

[4]Thanks to Dr. S. Malone and Dr. J. Zollweg for supplying the seismic data base.
[5]Thanks to Dr. J. A. Hynek and Dr. D. R. Saunders for supplying the UFO data base.

total of 278 general UFORs were determined for this period compared to 332 total entries.

The second UFO measure was called luminosity reports (LRs). It involved the total numbers of Types 3, 4, 5, and 6 UFOCAT events. They included the following perceptual characteristics: "the UFO moved in a non-continuous trajectory with a single discontinuity" (Type 3), "the UFO moved in a non-continuous trajectory with more than one discontinuity" (Type 4), "the UFO entered the frame of reference of the witness" (Type 5), and "the UFO landed or was seen adjacent to the ground" (Type 6). This cluster was chosen since it constituted a more or less homogeneous range of events that had been classified by CUFOS criteria and in turn defined classic UFO displays. Its disadvantage involved the relatively small numbers of cases ($n = 119$) and the possobility that many events actually belonging to the set remained within the unclassified category. The correlation between the general UFORs and LRs was 0.80 while both the general UFORs and LRs correlated only 0.43 and 0.40, respectively, with the residual Type 0, 1, and 2 reports. To attenuate problems of skewness, the monthly numbers of UFORs were truncated at 20 (this involved only two months for general UFORs). In a separate analysis, square root transformations were performed for both general UFORs and LRs to compare the effects of truncation (if any) with direct transformation.

All seismic events ($n = 1{,}414$) with magnitudes of 1.0 or greater were sorted from the University of Washington data base for the period of analysis. They were further sorted into the numbers of $1.0 \leq M < 2.0$ quakes per month (total = 1,009) and the numbers of $M \geq 2.0$ quakes per month (total = 405). This differentiation allowed a test of whether or not UFORs were maximally correlated with events of smaller magnitude, often indicative of changes in initial levels of strain rather than events of larger magnitude. In addition, the numbers of events of III to V intensity were selected from a previous data file (Persinger, 1980) to verify the failure to demonstrate any significant seismic UFOR correlation. They involved a total of 40 reports.

Two seismic models were calculated from the data base using $M \geq 2.0$ quakes only: (1) the magnitude of a quake as the exponential to its depth in kilometers (D^M) and (2) the magnitude of a quake as the exponential to 10 (10^M). The sums of D^M per month and 10^M per month were used as indices for the monthly release of "seismic energy". These two operations were selected since the former had been indicated where UFORs were used as a relative point of reference (small locus) with respect to the larger surrounding area in which the majority of the earthquakes occurred. In addition, this measure selectively amplified strong, deep quakes relative to those with epicenters closer to the surface. Because the range in the values obtained was large, log (base 10) values were taken; they did not display excessive skewness values (<

1.00). The few months in which no $M \geq 2.0$ quakes occurred were assigned a minimum value of 100 ($\log = 2$).

All previous approaches assumed a fixed relationship between the lag in UFORs and the seismic measure. Since it was possible that the optimal lag was not fixed but variable (and systematically associated with the amount of energy released), special analyses were completed. The total interval of 72 mo. was divided into 6-mo. fixed periods (January to June, July to December). Within each interval, the month with the largest value for the log of the sum of 10^M or D^M was selected separately (to enhance visualization of any potential effect). Using these months as references, the optimal lag in UFORs was determined by finding the month before the seismic key month in which a maximum inflection point occurred in numbers of UFORs regardless of absolute values. The inflection-point criterion was any month in which the UFORs were at least a factor of 2 larger than values for the month that came after it and before it. Selection of this month was programmed for the computer. If this criterion was not met within 6 mo. then the maximum lag was designated as zero (the same month as the maximum value for the seismic measure). As a control procedure, the same operation was applied to the 6-mo. sequence *after* each seismic key month.

Previous analyses based on the central region of the USA (Persinger, 1983c) have clearly indicated that percentage changes in the numbers of felt earthquakes from the previous increment are also correlated ($r = 0.70$) with both percentage changes and absolute numbers of UFORs. Such correlations may help indicate the nature of the mechanisms by which UFORs are generated. For example, if maximal UFORs occur before or during increases in numbers of earthquakes of a particular magnitude, regardless of the absolute numbers of quakes per increment, then *changes* in strain rather than some absolute measure are strongly implicated in the genesis of UFORs. Percentage change variables are also useful for data bases within which a sudden shift in absolute numbers of UFORs based on alterations in data source or sampling, destroy or mask the relationship (Persinger, 1983c).

Consequently two types of change variables were calculated for the numbers of general UFORs, LRs, $1.0 \leq M < 2.0$ quakes and $M \geq 2.0$ quakes. The first involved the percentage change from the previous increment and was calculated for each variable by subtracting the value for the previous increment (lag = 1) from the contemporary value, dividing that quantity by the value from the previous increment and multiplying by 100. This calculation, called percentage change has been described previously for other measures (Persinger, 1983a). Since some increments contained values = 0, + 1 was added to the monthly values of each of these variables to eliminate a possible 0 in the denominator. The quotients were truncated at 200%; this resulted in skewness values well within accepted limits (< 1.00).

The second change variable was obtained by calculating the ratio of the change in numbers of UFORs or quakes from the previous increment. Because there were more zeros and extreme values in the luminous reports, this measure was not calculated for them. The advantage of the ratio measures was their potential for direct application when regression coefficients are calculated; their primary disadvantage was the excessive skewness (> 2.00) since the ratios ranged from <1 to 10.

Other analyses have emphasized the importance of combining two components of a geophysical factor in a non-linear fashion to optimize the key source of variance. In the present analyses, an earthquake measure was calculated by taking the square root of the numbers of $M \geqq 2.0$ quakes per increment to the exponential 1.5 plus the numbers of $1.0 \leqq M < 2.0$ quakes per increment to the exponential of 2.0. This value, which weights the numbers of smaller quakes over the larger quakes still accommodates the numbers of events of larger magnitude. Percentage-change values from the previous increments were also calculated for this measure.

Considering the many analyses that have yielded relationships for lag (or lead) between UFORs and seismic measures, "symmetrical lag/lead" procedures were completed (Persinger, 1981). By comparing lag 3 of the UFOR measures with the contemporary measure and lags 1 to 6 of the earthquake measures, one can determine whether UFORs occurred maximally before or after the seismic measures. Identification of the maximum distribution of UFORs in time with respect to the occurrence of seismic measures is important for supporting the strain hypothesis and for the potential usefulness of UFORs as predictors of seismic events. These analyses were completed by using the LAG and PEARSON CORR features of SPSS. Since one lag may not contain all the variance, stepwise multiple regression (SPSS Program, REGRESSION) was also used with the UFOR measures as dependent variables and the six lags plus the contemporary seismic variable as the independent variables to determine the maximum explained variance before the r^2 values asymptoted. All analyses were completed on a DEC 2020 system computer.

RESULTS

No statistically significant ($p > .01$) correlations were found between the D^M or 10^M measures or their lags and the numbers of general UFORs when fixed (1-mo.) increments of analysis were used for the period, 1970 to 1976. Fig. 1 contains the total numbers of general UFORs per month and the log of the sums of 10^M values for all seismic events ($M \geqq 2.0$) per month. However, close scrutiny of the data indicated variable lags that were a function of the magnitude of the 10^M index for the seismic key months. The larger the display of seismic energy within the single most robust month of each 6-mo. sequence, the more antecedent the lag of the previous maxima (inflection

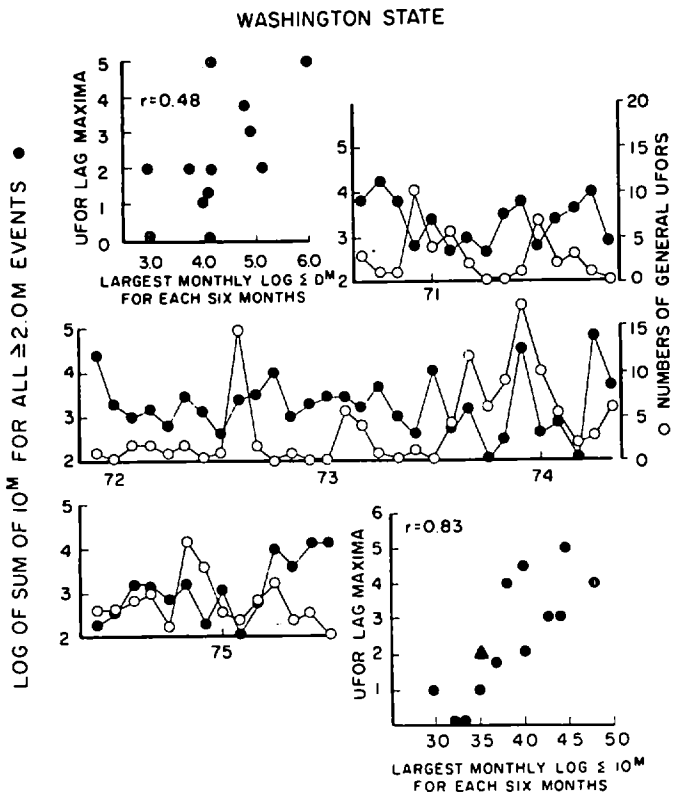

FIG. 1. Log of the sum of earthquake magnitudes to the exponential of 10 (10^M) for all events with M ≧ 2.0 (closed circles) per month and the total numbers of general UFORs (open circles) per month between September 1970 and July 1975. The upper insert shows the relationship between the largest monthly log of the sum of quake depths with the magnitude as the exponent (D^M) per 6-mo. series (see text for explanation) as a function of the time lag (in months) since the previous peak in the numbers of UFORs. The lower insert demonstrates the scattergram between the largest monthly log of the sum of 10^M for each 6-mo. sequence and the time (in months) since the last peak in numbers of UFORs.

point) in the numbers of general UFORs. As can be seen in Fig. 1 (lower insert) the correlation was strong (0.83). A similar relationship occurred with the D^M index (upper insert) but was much smaller ($r = 0.48$). Since the maximum 10^M value for one of the 6-mo. sequences occurred the month after the maximum value for the previous 6-mo. sequence, the second highest value was chosen for that interval. However, if that value had been selected (triangle in Fig. 1), the strength of the relationship would not be altered.

There were no significant correlations between the magnitudes of the indices for the seismic key months and the peak in UFORs for the *following*

series of 6 mo. The correlation for the magnitudes of D^M and 10^M was 0.72 ($p < .001$).

Bivariate analyses between the numbers of general UFORs and the various lag/lead seismic variables indicated that the most statistically significant ($p < .01$) correlation occurred with lag = 0 between the measures of events of small magnitude. Neither the numbers of quakes of larger magnitudes nor the numbers of felt quakes (measured by maximum intensity) were significantly correlated with numbers of UFORs. However, multiple regression analyses indicated that earthquakes of larger magnitude within the three months following UFORs contributed a small but cumulative variance that was not evident with the numbers of quakes of small magnitude. The asymptote r^2 values when all lag/lead variables for the numbers of $M \geq 2.0$ quakes entered were about 25% and involved the three months after increases in UFORs; a similar pattern was noted for the log of the 10^M measure. Results comparable to those for the entire interval (1970 to 1976) were also noted for the four last years (1972-1976). The latter analysis was completed since a weak but statistically significant ($p < .01$) increase in the slope of UFOR numbers over time ($r = 0.30$, $df = 70$) occurred within the earlier but not the later interval.

Fig. 2 displays the total numbers of UFORs and quakes of large and small magnitudes per month. Visual inspection of the data indicated that one optimal increment was greater than 1 mo. and less than 6 mo. The data series were partitioned into clusters defined as the beginning and the end of a UFOR series (trough to trough duration). The mean and the standard deviation of the cluster duration was 3 ± 1.5 mo. Numbers of UFORs (truncated at 30) and $1.0 \leq M < 2.0$ quakes and $M \geq 2.0$ quakes were summed for each cluster. As can be seen in the insert in Fig. 2, the correlation was strong between the numbers of $1.0 \leq M < 2.0$ quakes per cluster and numbers of UFORs per cluster. The correlation is 0.69 ($df = 17$); if the two outliers are not included, the r value is 0.86. The numbers of larger quakes per cluster gave a much weaker and non-significant correlation ($r = 0.35$) with UFORs while the two quake measures were significantly correlated ($r = 0.65$, $p < .01$). Square roots of the total UFORs (no truncation) displayed rs within a range of ± 0.05. Fig. 3 displays a similar relationship between the measures for earthquakes (a weighted combination of the quakes of large and small magnitudes) and general UFORs. The numbers of felt events (intensity, indicated by solid bars) are also indicated.

Visual inspection of Figs. 2 and 3 also indicate that general UFORs tended to increase during months where there was a sudden increase in the numbers of events of small magnitude. Correlational analyses verified this association (Table 1). The maximum and most statistically significant lag between the percentage change in UFORs and the percentage change in small quakes or the

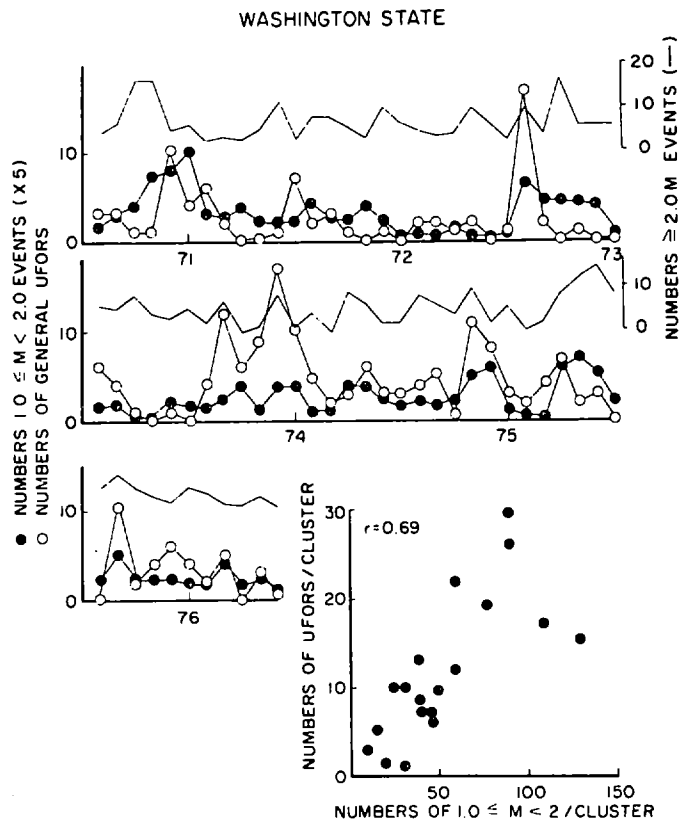

FIG. 2. Numbers of general UFORs (○) numbers of seismic events $1.0 \leqq M < 2.0$ (●) and numbers of $M \geqq 2.0$ seismic events (—) per month between late 1970 and early 1976 for Washington state. The lower insert contains the scattergram of the numbers of UFORs per cluster (about three months) and the numbers of $1.0 \leqq M < 2.0$ quakes per cluster during that period.

earthquake measure was 0. Addition of other lags did not appreciably alter the values of multiple r^2. Months in which there was a significant increase in UFORs with respect to the previous month were also associated with increased numbers of quakes of small magnitude over those of the previous month. The maximum values of r for the two intervals for the quakes of small magnitude and the composite earthquake measure, which was loaded heavily by and correlated strongly with (0.96) quakes of small magnitude, were 0.42, 0.53, 0.45, and 0.60 ($p < .001$), respectively. Use of ratios of change, although excessively skewed, neither attenuated nor enhanced the strength of the relationship.

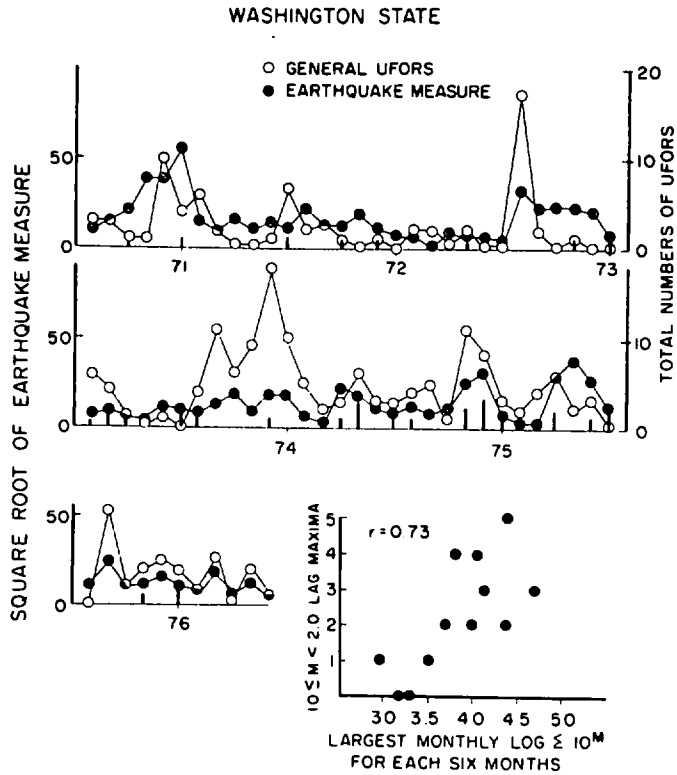

FIG. 3. Numbers of UFORs per month (O) and the value of the earthquake measure per month (●) over the observation interval. The vertical bars indicate the occurrence of III, IV, or V intensity quakes, which ranged from 0 to 3 per month. The lower insert is a scattergram of the relationship between the largest monthly log of the sum of 10^M (M = magnitude) for all $M \geq 2.0$ events per month during the six-month sequences and the time lag (in months) since the last peak in the numbers of small magnitude earthquakes ($1.0 \leq M < 2.0$).

Fig. 4 contains a graphic display of the relationship. There was a clear coherence in the change (either increase, decrease or no change) between the numbers of general UFORs and the values of the earthquake measures, even when the magnitudes of the changes were not very similar. Spearman rank order correlations between these measures of change in UFORs and seismic activity for the two intervals confirmed this statement ($\rho s = 0.54$ and 0.65, respectively), although they were not significantly ($p > .05$) larger than the Pearson rs. Fig. 4 also contains the percentage change values for the earthquake measure for the months after the end of the UFOR data files. The regression coefficient for the change in UFORs with respect to the change in the earthquake measure for the period of analysis was 50%, with a standard error

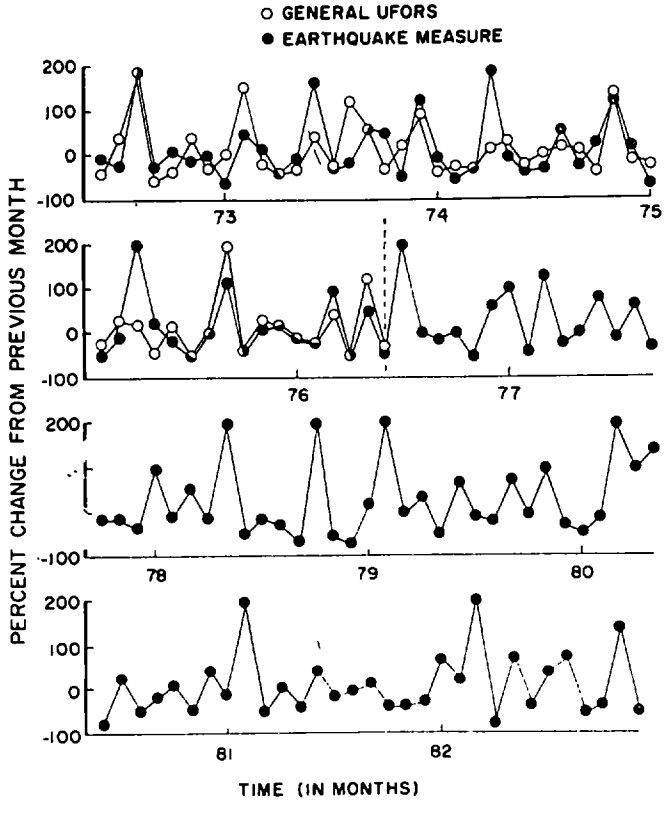

FIG. 4. The percentage change in the numbers of general UFORs with respect to the previous month (O) and the percentage change in the values of the composite seismic earthquake measure with respect to the previous month (●) between June 1973 and June 1976. The percentage change values for the earthquake measure are extended to the end of 1982.

of the estimate of 52%. This indicates that for every 100% increase in the seismic measure from the previous increment, there should have been a 50% increase in UFORs from the previous increment for those intervals. However, considering the high standard error of the estimate, the more confident values would be for those months exceeding 100% change.

If the percentage change in numbers of UFORs from the previous month is that tightly coupled with the percentage change in quakes of small magnitude from the previous month for the intervals, we expected that the quakes of small magnitude should also be lagged in time (variably) in a manner similar to the UFORs (Fig. 1). Consequently, the inflection point of the numbers of small magnitude and larger magnitude quakes were calculated using a criterion similar to the one employed for the UFORs. The results are noted

TABLE 1

CORRELATIONS BETWEEN NUMBERS OF SMALLER MAGNITUDE ($1.0 \leq M < 2.0$) SEISMIC EVENTS, GREATER MAGNITUDE ($M \geq 2.0$) EVENTS, INTENSITY (BETWEEN III AND V; MODIFIED MERCALLI) EVENTS AND VALUES OF COMPOSITE QUAKE MEASURE AND NUMBERS OF GENERAL UFORS AND LRS AND CHANGES IN THESE MEASURES (UFORCH AND LRCH) FROM THE PREVIOUS MONTH FOR TWO INTERVALS 1970-1976 AND 1973-1976

Measures	($n = 72$ mo.)				($n = 48$ mo.)			
	UFORS	UFORCH	LR	LRCH	UFORS	UFORCH	LR	LRCH
Quake Measures								
Numbers of $1.0 \leq M < 2$	0.26	0.16	0.26	0.09	0.29	0.25	0.41	0.21
Numbers of $M \geq 2$	–0.01	0.09	0.02	–0.00	0.10	0.17	0.15	0.04
Reports of Intensity	0.17	0.16	0.20	0.18	0.11	–0.10	0.08	–0.01
"Quake Measure"	0.25	0.16	0.27	0.10	0.28	0.25	0.40	0.20
Relative Changes From Previous Month								
% Change, $1.0 \leq M < 2$	0.35	0.42	0.41	0.41	0.52	0.53	0.46	0.54
Ratio $1.0 \leq M < 2$	0.31	0.35	0.36	0.28	0.51	0.52	0.36	0.35
% Change, $M \geq 2.0$	0.25	0.13	0.25	0.13	0.21	0.18	0.29	0.23
% Change, Quake Measure	0.40	0.45	0.46	0.41	0.46	0.60	0.52	0.57

Note.—Correlations between percentage change from the previous month and the absolute ratio of the change from the previous month for the numbers of small magnitude events and the percentage change in the larger magnitude and composite measures with respect to the numbers of UFORs and LRs and their measures of relative change (UFORCH and LRCH) are also shown for these periods.
$r > 0.30$, $p < .01$.
$r > 0.40$, $p < .001$.

in the insert in Fig. 3. As predicted, the larger the imminent display of seismic energy as measured by 10^M the larger the lag in the inflection point for the change in quakes of small magnitude ($r = 0.73$, $p < .01$). There was no significant correlation between the months of the largest seismic index value and the lags in quakes of large magnitude, since the inflection points were all contemporary (the largest numbers of quakes of the larger magnitude occurred during the same months as the maximum 10^M values). The means and standard deviations for the numbers of lags for the UFORs and of quakes of small magnitude were 2.5 ± 1.7 and 2.3 ± 1.6, respectively. A t test indicated that

the difference was not statistically significant ($t < 1.00$, $p > .05$, $df = 10$).

The relationships between each of the various seismic measures and the numbers of luminosity reports, which were differentiated as a check for the internal consistency within a more homogeneous subsample of the general UFORs, were similar to those for the larger population. A statistically significent ($p < .01$) but weaker ($r = 0.68$) correlation was obtained between the 10^M measures and the maximum lag inflection point for the numbers of LRs. In addition as can be seen in Table 1, the quakes of smaller magnitude were also highly correlated with changes in the numbers of LRs. Even the *numbers* of LRs were significantly ($p < .001$) correlated ($r = 0.41$) with the numbers of quakes of smaller magnitudes. Interestingly, for a *fixed* 3-mo. interval of analysis also the correlation was significant ($p < .01$) between LRs and

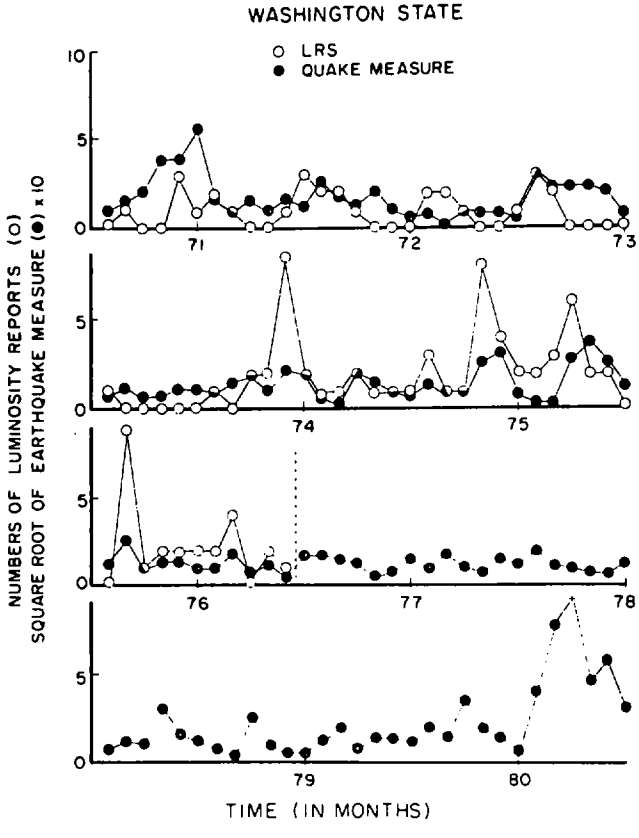

FIG. 5. Total numbers of luminosity reports (LRs) per month and the values for a composite measure of the numbers of small and large earthquakes per month between August 1970 and June 1976. The earthquake measure is extended to within the period of the Mt. St. Helens eruption (the plus, which is off scale).

the numbers of quakes of the smaller magnitude ($r = 0.60$) but not with the quakes of the larger magnitude ($r = 0.30$).

Fig. 5 contains data for the numbers of LRs (Type III to Type VI from the UFOCAT, CUFOS data base) and the earthquake measure. The coherence in the relative changes in numbers of luminosity reports and the values of the earthquake measure are evident. Specific coefficients are shown in Table 1. For possible use in verification from future additions to the CUFOS data base, the calculated values for the earthquake measure for the months leading to the eruption of Mt. St. Helens (asterisk) are also plotted.

Discussion

The present analyses contribute further empirical support to the logical extrapolations of the tectonic strain hypothesis for UFORs. Although the general relationship between the major portion of variance in UFORs and the primary measure from which inference of tectonic strain is made, i.e., earthquake measures, should be evident *anywhere*, the specific relationship should vary among areas of different geology and states of stress. However, the pattern should be consistent within an area. The numbers of quakes of various intensities in this Washington-Oregon area, unlike other parts of the USA, were not sufficient samples of the total population of seismic events within Washington state to discern the relationship. When inclusive seismic measures from the University of Washington network were employed, the UFOR-seismic relationships were strong and intricate.

The second major consequence of the present analyses was the detection of variable lags between the magnitude of the larger interval (6 mo.) of energy release and the previous occurrence of peak UFOR numbers. Whereas UFOR peaks within 6-mo. sequences occurred during the same months as intermediate magnitudes of released energy (lag = 0), UFOR peaks tended to occur 4 to 5 mo. before the largest monthly values for displays of seismic energy. It would be interesting to determine whether the amplitude of the total population of UFORs, not influenced by sampling or collection variables, would also increase in a systematic manner with the magnitude of the imminent seismic display.

The discovery of an intermediate optimal increment of analysis that is somewhat variable and may shift in time has been suspected but not confirmed until now. Maximum bivariate correlations between UFORs and the quakes of smaller magnitude ($1.0 \leq M < 2.0$) occurred with approximately 3-mo. increments of analyses (that did not split the largest UFOR sequences but included them as 5- to 7-mo. units). There is a possibility that the longer increments may have artifactually elevated the numbers of reports and events in the calculation and spuriously increased the correlations. An index correlation may have been introduced since both variables would have shared a common

implicit denominator (changing increments of analyses). However, the correlations between UFORs and quakes of the larger magnitude ($M \geqq 2.0$) were not statistically significant, although positive, for the same increments. In addition, even the use of fixed 3-mo. increments of analyses gave significant correlations between LRs and the numbers of events of small magnitude.

Previous analyses have included total UFORs, a practice that may have: (1) increased the heterogeneity of the sample and lowered the potential correlation with seismic indices, or (2) introduced confounding variables, such as the propensity to report "odd things" (if systematically associated with later seismic activity, the mechanism would be particularly interesting). The inclusion of non-tectonogenic UFORs would not significantly alter the results of previous reports if one assumes that the "noise" occurred in a random manner and was "cancelled out" within the longer (6-mo.) increments of the present analysis. In this study, both general UFORs, which did not include non-UFO reports or more well known sources of conventional stimuli, and the very select subcluster (LRs), which were definitely categorized within a traditional luminosity (Persinger, 1983b) framework, showed association with seismic factors. These reports tended to occur several months before a large increase in the amount of seismic energy was displayed within the area but during the same months as increases in small magnitude events.

Certainly there were sources of variance and at least one clear discrepancy in UFORs that appeared to diverge from a quantitative coupling to seismic factors. Sometimes there were fewer UFORs than would have been expected from the numbers of small quakes. This may reflect an overinclusive range of magnitudes of quakes selected for correlation with UFORs, or, a lack of observation or report of the alleged veridical events that we assume are associated with UFORs. The most blatant deviation is the greater than expected numbers of UFORs during late 1973. It is not clear whether these elevations reflect an alteration in the data collection, the exclusion of some other seismic variable or the transient occurrence of still some other stimulus.

Previous analyses have indicated the involvement of some factor associated with geomagnetic variations as defined by the Ap indices (available in the *Journal of Geophysical Research*). The occurrence of a geomagnetic storm (daily Ap indices greater than 50) or unusually active single days (Ap values greater than 100) within a month, appear to facilitate UFORs assuming the state of tectonic stress, as inferred from the latter enhancement of seismic activity, is increasing. Measures of geomagnetic variation were not employed in the present paper. Although months containing elevated Ap values (especially *after* several months in which there had been relatively quiet geomagnetic conditions) were coincident with all of the major, sudden increases in the numbers of UFORs, this variable would not accommodate all of the discrepancy within the 1973 episode.

The visually and statistically significant relationship between the percentage change in UFORs from the previous month and the percentage change in events of small magnitude emphasizes two features. First, UFOs may be associated with the same tectonogenic process that evokes $1.0 \leq M < 2.0$ events within Washington state. When this process (which has been hypothesized to reflect some *general strain factor*) is clearly specified, a more exact prediction of UFOR characteristics may be possible. Previous studies (Persinger, 1980) involving other areas have also shown UFORs to be correlated strongly with quakes of smaller intensity (IV-V or less) but not with VI or greater reports. Once the transformations by the local geology and state of stress are accommodated, one general process may be evident in all areas.

The second feature is the possible use of UFORs and quakes of small magnitude as predictors of large releases of seismic energy. In the present study, both changes in the numbers of UFORs or LRs and the numbers of seismic events of the smaller magnitude were moderately and consistently correlated; both were strongly correlated with the imminent release of large seismic energies. Since the average lag was about 2 months before the larger releases and more than 4 months for the largest monthly releases, human behavior as measured by UFORs, could be useful as an ancillary measure for the prediction of certain types of large seismic events.

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